COVID-19 prevention, treatment, and rehabilitation: a scoping review of key concepts for future pandemic preparedness

Introduction

SARS-CoV-2 was first identified in December 2019 in Wuhan and soon became a global public health issue [1, 2]. The coronavirus disease, or COVID-19, causes flu-like symptoms such as fever, dry cough, dyspnea, and fatigue and can lead to life-threatening pneumonia [3]. The clinical spectrums range widely from asymptomatic infections to severe illness. Up to 80% infected by the virus could have had no symptoms or mild-to-moderate symptoms [4,5]. Severe illness and death due to infection were more likely to occur with increasing age and comorbidities [5]. By June 2023, the COVID-19 pandemic had resulted in 6.94 million deaths globally, according to the World Health Organization [6]. In Europe alone, there were 276 million confirmed cases and 2.24 million deaths during the various pandemic waves between February 2020 till January 2022 [8]. Italy and Spain reported a higher number of deaths than Germany and the Netherlands. The European countries were impacted significantly in different ways and times. Various parameters and reporting structures were introduced at both national and international levels to quickly identify and minimize the impact of the virus [9]. Table 1 shows the impact of the pandemic in four European countries.

	ITALY	**SPAIN**	**GERMANY**	**NETHERLANDS**	**EU**	**WORLD**
Population	59.030.133	47.432.893	83.237.124	17.590.672	447.700.000	
Cases	25.870.833	13.890.555	38.429.922	8.610.372	276.585.359	767.750.853
Deaths	190.517	121.416	174.412	22.992	2.240.485	6.941.095

Table 1. COVID-19 in numbers. Data on population size, cases, and mortality from the partner countries of GLIDE-19 project [6,7, 8].

Prevention

In the initial stages of the COVID-19 pandemic, stopping the spread of the infection took precedence. To prevent the spread of the coronavirus, several protective measures were introduced, such as wearing masks in public, hand hygiene and disinfection and ventilation of public areas and objects. Moreover, social distancing was implemented through restrictions on personal mobility; further measures included border control and closure of public transport, workplaces, and schools; isolation of cases, contact tracing, screening testing and quarantine.

Although physical distancing was the primary measure adopted by many European governments at the onset of the pandemic, compliance with these measures varied significantly among individuals. Mortality and virus transmission rates in relation to social distancing measures (particularly

lockdown) showed a decrease in mortality rates in Italy and Spain [10] and a 1.27 lowering of the R0 index in Italy (pre-lockdown 2.03, post-lockdown 0.76) [11]. With the advent of COVID-19 vaccines by December 2020, mass vaccination plans were launched in several countries [12]. The vaccines became an essential tool to significantly reduce COVID-19 cases, hospitalizations, and deaths. Large-scale clinical trials and real-world data have shown that COVID-19 vaccines are safe, well-tolerated [13] and highly effective in preventing COVID-19 infections, severe disease, hospitalizations, and deaths caused by the virus.

Treatment

Treatment protocols for COVID-19 infections varied throughout the pandemic as several variants of SARS-CoV-2 emerged. Initially, due to the lack of specific preventive and therapeutic measures various preexisting medications have been used "off-label" for the treatment of patients infected with SARS-CoV2. Choice of drugs, possible combinations, dosages, and duration of treatment have been based on physician opinion and previous experience with similar conditions. The medications used combine antiviral activity, immunomodulatory action and inhibition of pro-inflammatory cytokines [21]. However, the scientific evidence supporting the use of these has been limited.

Rehabilitation

As the pandemic progressed, reinfections and persisting cases gave rise to the challenges of so-called “Long”- or “Post-COVID” syndromes and the psychological impact of the pandemic.

While most patients recover within a few weeks after acute infection, evidence quickly emerged that some people report persistence or development of various symptoms of varying intensity, regardless of the severity of their initial symptoms. The condition was named post COVID syndrome, characterized by the continuation or development of new symptoms for at least 2 months after the initial infection. More than 17 million people in the WHO European Region may have experienced post COVID syndrome during the first two years of the pandemic [14].

Aims and objectives

This scoping review presents an overview of a large body of literature on the COVID-19 pandemic, aimed at identifying and synthesizing evidence-based guidelines for the prevention, treatment and long-term care related to COVID-19 in the European context using the examples of Italian, Spanish, German and Dutch policies and experiences. Moreover, it identifies the psychosocial and educational lessons learnt during the COVID-19 pandemic. The aim is to provide an overview for the management of COVID-like situations in case of future pandemics. Recognizing European countries` errors and best practices is a promising step towards better management of future challenges.

Methods

This scoping review was conducted as part of the GLIDE-19 project, which is a collaboration of four different European institutions and funded by the European Union's Erasmus+ program (2022-1-IT01-KA220-VET-000088032). Each partner of the GLIDE-consortium retrieved articles on one of the four main themes: prevention (Heidelberg), care (Italy), long-term treatment (Netherlands) and psychosocial impact (Spain) of the Covid-19 pandemic.

Search Strategy

We searched the databases of PubMed, EBSCO and Cochrane using several combinations of keywords related to COVID-19 prevention, care and rehabilitation. We present our search strategy in a supplementary file. The combined searches resulted in 554 articles. The results were filtered for papers published in English, German, Italian, Spanish and Dutch until 31.12.2022. After titles and abstracts screening, 130 papers were selected for full-text screening. 82 articles were eligible for the scoping review. Gray literature (non-research evidence) on guidelines was retrieved from reports by each country's main institution for pandemic management, ECDC and WHO.

Study Selection

Studies that met the following criteria were included: (1) studies reporting at least one of the following types of information: best practices on prevention, treatment, or COVID-19 rehabilitation; (2) study designs: any existing literature (qualitative and quantitative studies), in case of too many results search was limited to: reviews and meta-analyses till 31.12.2022 and original research papers from 01.08.2022 to 31.12.2022; and (3) any type of population, in case of too many papers the search was narrowed down to healthcare professionals and social workers.

Studies were excluded on the basis of one or more of the following: (1) studies that did not include at least one European country; (2) non-English, Italian, Spanish, German or Dutch articles.

Data Extraction and Synthesis

Data extraction for each article was performed using Microsoft Excel that included literature characteristics (eg, journal, year of publication, title, authors), characteristics related to study method (eg, article type, country where the study was conducted or included countries, healthcare setting), and key findings. As the data extraction process unfolded, we also enhanced the data extraction form, with new or more precise categories as needed. Reviewers had regular meetings to address any challenges and to ensure concordance with their abstraction methods.

For data analysis, we descriptively summarized the data. The findings are presented in a narrative form.

Results

Prevention

This part focuses on prevention of COVID-19 infection. Based on research findings, control measures and best and worst practices in response to the COVID-19 pandemic are considered.

A paper by Bahl and colleagues showed that SARS-CoV-2 can be detected in the air, and remains viable 3 hours after aerosolization. The transmission of COVID-19 is likely similar to SARS, which can spread through contact, droplets, and airborne routes. Airborne transmission is possible due to the presence of viral loads in the respiratory tract and the persistence of the virus in the air. They suggest precautions against airborne dispersal for the occupational health and safety of health workers treating patients with COVID-19 [15].

A survey conducted online with over 2,000 adults living in North America and Europe aimed to study the adherence rates and factors influencing compliance with social distancing recommendations during the early stages of the pandemic. The results showed that people's adherence to these recommendations varied significantly among individuals and may depend on the specific actions they are being asked to take. The most effective factors that promoted adherence to social distancing guidelines include a desire to safeguard oneself, a sense of responsibility to protect the community and the ability to work or study remotely. The most significant obstacles to compliance were having friends or family who required assistance and a need for social interaction to avoid feelings of isolation. To enhance adherence to social distancing measures, future interventions should combine personalized approaches aimed at overcoming the identified barriers with institutional measures and public health interventions [16].

Identifying secondary cases before the onset of infection by setting up quarantine and testing, is a prevention measure that was heavily invested in during the early stages of the COVID-19 pandemic, in particular by developing digital contact tracing apps. However, the international experience of digital contact tracing apps during the COVID-19 pandemic demonstrates how challenging their design and deployment are. In particular, main challenges regard ethical issues such as data protection and privacy. In this field there is potential for promising advancements through the integration of blockchain technology, ultra-wideband technology, and artificial intelligence in app design [17].

In vaccination campaigns, prioritization of certain population groups can influence the success of the campaign itself. A study which evaluated the vaccine allocation in Rhode Island and Massachusetts found that allocating a substantial proportion of vaccine supply to individuals at high risk of mortality is an effective strategy for reducing total cumulative deaths. The study suggests that a median of 327 to 340 deaths could be avoided in Rhode Island by optimizing vaccine allocation and vaccinating the elderly first. While the study focuses on individuals over the age of 70, the results could be applied to other high-mortality groups (i.e. obesity, diabetes, past lung disease, lack of healthcare access) by allocating a higher proportion of vaccines to them. However, it's important to note that the study did not explicitly model other high-mortality groups, so the results would need to be interpreted with caution. In addition, individuals who have high-contact rates with high-mortality risk groups or cohabit with them should similarly be prioritized for vaccination. Although, vaccination of only high-contact groups can’t be considered as one of the

best practices mainly due to the wide mortality differences between the youngest and oldest age groups [18].

Treatment/care

Patients with a SARS-CoV-2 infection can experience a wide range of clinical manifestations, ranging from no symptoms to critical illness. Common symptoms include fatigue, fever, cough, loss of smell or tasting, and headache, among others. In addition, approximately 30% of patients also reported gastrointestinal symptoms such as diarrhea, nausea, and stomach pain [19].

In general, adults with SARS-CoV-2 infection can be grouped into 5 severity categories [19]:

- Asymptomatic or pre-symptomatic infection, positive test for SARS-CoV-2 but no symptoms consistent with COVID-19.
- Mild illness, individuals who have any of the various signs and symptoms of COVID-19 (e.g., fever, cough, sore throat, malaise, headache, muscle pain, nausea, vomiting, diarrhea, loss of taste and smell) but do not have shortness of breath, dyspnea, or abnormal chest imaging.
- Moderate illness, evidence of lower respiratory disease during clinical assessment or imaging and oxygen saturation ≥ 94% on room air at sea level.
- Severe illness, previous listed symptoms, breathlessness and increased respiratory rate which may indicate pneumonia and oxygen need.
- Critical illness, individuals who have respiratory failure, septic shock, and/or multiple organ dysfunction requiring intensive support [19].

It's important to differentiate between these conditions because they require different patient management. Therefore, there are three targets for current SARS-CoV-2 infection:

- Asymptomatic or symptomatic infection of any severity.
- Mild or moderate COVID-19 disease.
- Severe or critical COVID-19 pneumonia [19].

Bellino [20] reports that the majority of COVID-19 patients experience mild to moderate symptoms and can recover without needing special treatment. However, up to 15% of patients may develop severe or critical symptoms. Even though vaccination has significantly reduced the number of COVID-19 cases, hospitalizations, and deaths, managing severe cases remains a challenge due to the multisystemic nature of the infection, which can affect several body systems. This was especially true during the first stages of the pandemic, during which due to the lack of specific preventive and therapeutic measures various preexisting medications have been used "off-label" for the treatment of patients infected with SARS-CoV2. COVID-19 has been treated with antivirals, immunomodulators, antibiotics, stem cells, plasma therapy and others [21]. Each of these treatment methods has benefits and drawbacks and their effectiveness varies depending on the specific medication, the severity of the disease, and the stage of the illness. In summary, as reported in a review of Haddad and colleagues [22] some antiviral agents, such as Remdesivir, Ivermectin and Lopinavir have shown some effectiveness in reducing the duration of hospitalization and improving clinical outcomes in hospitalized patients with severe COVID-19.

Corticosteroids usage, such as dexamethasone, is supported by robust evidence and has been shown to reduce mortality in critically ill COVID-19 patients. However, the use of other medications, such

as immunomodulatory and anti-inflammatory drugs (Tocilizumab, sarilumab, Chloroquine) is quite conflicting. Moreover, conflicting data are present on the usage of convalescent plasma and vitamin D [22]. In Table 3 more findings on other medications and their efficacy are reported. Subsequent randomized studies are needed to warrant the determination of their usefulness.

Active principle	Classification	Usage as Covid-19 treatment
Remdesivir	Antiviral	Emergency use authorization by FDA
Lopinavir/ ritonavir	Antiviral	Positive effects
Favipiravir	Antiviral	Positive effects
Molnupiravir	Antiviral	Emergency use authorization by FDA
Paxlovid	Antiviral	Emergency use authorization by FDA
Ivermectin	Antiviral	Contradictory results
Interferons	Antiviral	Positive effects
Dexamethasone	Immunomodulator	Positive effects
Hydrocortisone	Immunomodulator	Lack of studies
Methylprednisolone	Immunomodulator	Lack of studies
Budesonide	Immunomodulator	Lack of studies
Ciclesonide	Immunomodulator	Contradictory results
Chloroquine and hydroxychloroquine	Immunomodulators	Clinical trials have been paused due to a lack of benefits for COVID-19 patients
Colchicine	Immunomodulator	Contradictory results
Tocilizumab	Immunomodulator (Monoclonal antibody)	Positive effects
Sarilumab	Immunomodulator	Positive effects
Anakinra	Immunomodulator	Ineffective
Baricitinib	Immunomodulator	Emergency use authorization by FDA
Tofacitinib	Immunomodulator	Positive effects
Ruxolitinib	Immunomodulator	Ineffective
Thalidomide	Immunomodulator	Positive effects
Canakinumab	Immunomodulator (Monoclonal antibody)	Positive effects

Bamlanivimab and etesevimab	Immunomodulator (Monoclonal antibody)	Not approved at the time of the review publication
Bevacizumab	Immunomodulator (Monoclonal antibody)	Positive effects
Casirivimab and imdevimab	Immunomodulator (Monoclonal antibody)	Not approved at the time of the review publication
Ticagevimab and cilgavimab	Immunomodulator (Monoclonal antibody)	Emergency use authorization by FDA
Bebtelovimab	Immunomodulator (Monoclonal antibody)	Emergency use authorization by FDA
Azithromycin	Other	Ineffective
Convalescent plasma therapy	Other	Positive effects
Mesenchymal stem cells	Other	Positive effects

Table 3. Summary of the efficacy of several pharmacologic agents for the treatment of COVID-19 adapted from "A Comprehensive Review on the Efficacy of Several Pharmacologic Agents for the Treatment of COVID-19", Haddad et al., 2022. For all of the listed agents further randomized studies are necessary to support their usage [22].

In addition, to explore the efficacy of existing drugs, scientists worldwide tried to develop new treatment options, such as new drugs, immunotherapies, and host directed therapies.
These treatments can be divided into two main categories: those that directly target the virus replication cycle, and those that aim to boost the immune response or reduce inflammation [23]. Two main processes are thought to drive the pathogenesis of COVID-19. During the early stages of COVID-19, the virus replication is the primary cause of the disease, and drugs such as antivirals are likely to be most effective. These work by preventing the virus from replicating and spreading throughout the body. As the disease progresses, however, the immune response can become dysregulated, leading to excessive inflammation and tissue damage. At this stage, treatments that focus on regulating the immune response or reducing inflammation may be more effective [24].

In addition to the drugs just discussed, and to the symptomatic treatment of most common clinical manifestations (antipyretics, analgesics and antitussives for fever, headache, myalgias, and cough), in accordance with the biopsychosocial model, the NIH guidelines [24] suggest holistic patient care. It's so essential to encourage patients to drink fluids regularly to prevent dehydration and rest as needed during the acute phase of the illness. Patients can gradually increase their activity level based on their tolerance. Psychological support is an essential aspect of caring for COVID-19 patients. The pandemic has led to significant levels of stress, anxiety, and depression. Patients with COVID-19 may experience fear, isolation and uncertainty which can contribute to their overall psychological distress. Therefore, it's crucial to provide psychological support, as well as video-based therapy in case of lockdowns, to help patients cope with their illness and its associated challenges. Psychological support can include interventions such as counseling, psychotherapy, and

cognitive-behavioral therapy, which can help patients manage their emotions, develop coping strategies, and improve their overall mental health. It's also important to provide patients with accurate and clear information about their illness, including its course, treatment options, and prognosis, to reduce anxiety and uncertainty [25].

In conclusion, according to the review of Pandolfi and colleagues [26], some main aspects on treatment policy for COVID-19 are:

1. Significance of post-mortem investigations on COVID-19-caused deaths in developing effective treatment protocols in the early stages of the disease based on its etiopathogenesis.
2. The early treatment of COVID-19 with common painkillers may not effectively address the illness and could even worsen SARS-CoV-2 symptoms in patients.
3. Importance of having a comprehensive understanding of the demographic composition of each country in order to implement effective safety procedures for at-risk groups, such as the elderly.
4. Decentralized medical coverage highly connected in large communities is better than centralized hospitals, in fact better management of decentralized medical resources could have prevented a significant number of hospitalizations, thereby reducing the mortality rate.
5. Sharing information, expertise, and skills between physicians and care personnel is crucial to speed up the development of a nationally agreed-upon and successful therapy protocol for COVID-19.

It's important to note that the best timing and combination of treatments for COVID-19 is still being studied, and treatment recommendations may vary depending on the severity of the disease.

Rehabilitation

Many patients with previous COVID-19 infection report persistent symptoms. The National Institute for Health and Care Excellence (NICE) in UK elaborated three possible conditions after the infection [26]:

1. Acute COVID-19, where signs and symptoms of the infection persist up to a maximum of 4 weeks.
2. Ongoing symptomatic COVID-19, where signs and symptoms of the infection last from 4 weeks to 12 weeks.
3. Post COVID-19 syndrome, in this condition signs and symptoms that develop during or after the infection, are present even after 12 weeks and can not be explained by an alternative diagnosis [27].

Post COVID symptoms are varied and can affect different organic systems. Therefore, the nature of these symptoms leads to the need of a holistic, tailored, and multidisciplinary rehabilitative intervention plan focused particularly on self-management [27]. UK National Health Service (NHS) guidelines propose 3 models for the management of post COVID patients, according to the severity of the acute infection and on whether the patient has been hospitalized [28]:

1. Non hospitalized patients. A central role in this scenario is played by the general practitioner, who must be adequately trained on the topic of post covid rehabilitation in order to identify those symptoms that may have been caused by the infection and play a connection between patients and needed specialists.

2. Patients who were hospitalized for COVID-19. These patients should undergo a 12-week post discharge assessment, comprising: chest X-ray and a review of symptoms for an eventual further continuation of the rehabilitation.
3. Patients who required intensive care unit (ICU) admission. They should undergo a multidisciplinary reassessment at 4-6 weeks post discharge. If conditions have improved patients will be treated like other hospitalized ones [28].

The World Health Organization (WHO) has identified the following conditions as the most important sequelae of COVID-19, that may require rehabilitative intervention [29, 30]:

- fatigue, exhaustion.
- breathing impairment.
- autonomic nervous system dysfunctions.
- post-exertional symptom exacerbation (PESE).
- dysphagia and dysphonia
- arthralgia
- olfactory impairment.
- cognitive impairment, such as: attention deficit, memory impairment, concentration impairment, executive dysfunction, cognitive communication disorder.
- other psychological disorders: anxiety and depression

Staffolani and colleagues in their comprehensive narrative review of 2022, revised possible treatments for most of the common post-covid manifestations [31]. According to this review, for symptoms like pain and myalgia, symptomatic treatment may be used, while for patients with pulmonary or neurologic sequelae chest physiotherapy and neurorehabilitation are useful. A multidisciplinary approach is recommended for respiratory symptoms, where non-pharmacological strategies such as breathing exercises, pulmonary rehabilitation, and postural relief may be helpful. Cardiovascular symptoms, such as tachycardia, may benefit from treatment with beta-blockers, while myocarditis usually resolves over time. For fatigue, cognitive and neuropsychiatric disorders, self-management, cognitive behavioral therapy, graded exercise treatment and pacing, may be used. Medications such as methylphenidate, donepezil, and modafinil may also be considered. Group therapy and supportive listening can also be effective. Sleep disturbances, post-traumatic stress disorder, depression, anxiety, and other mental health problems have to be managed according to specific guidelines. Emerging treatments such as hyperbaric oxygen, breath exercise, and singing are being studied to treat respiratory symptoms of Post COVID. Other adjuvant therapies such as vitamin C, nicotinamide, probiotic supplements, leronlimab, tocilizumab, melatonin, and others are also being studied. Home-based and community rehabilitation can be delivered through different strategies, such as tele--rehabilitation or direct care [32].

Social impact of pandemic and teaching methodologies to manage Covid in Europe

The psychological impact of COVID-19 pandemic is widely reported in the scientific literature. Already in 2020, Hossain and colleagues [33] suggested that a psychiatric epidemic was co-occurring with the COVID-19 pandemic, which necessitate the attention of the global health community. In particular, people affected by COVID-19 may develop mental health problems, including depression, anxiety disorders, stress, panic attack, irrational anger, impulsivity,

somatization disorder, sleep disorders, emotional disturbance, post-traumatic stress symptoms, and suicidal behaviour [33].
With regard to healthcare workers, the work overload, lack of resources and uncertainty caused by the COVID-19 pandemic, have generated feelings of fear, exhaustion, anxiety, frustration, and sadness [34].
In relation to the differences between frontline personnel and the rest of the professionals, Western studies showed that the greatest psychological impact occurred in cases of direct contact with infected patients [35].
According to a systematic review conducted by García-Iglesias and colleagues in 2020 [36], which analyzed 13 studies from around the world, healthcare professionals working on the front line during the SARS-CoV-2 pandemic experienced compromised mental well-being, with medium-high levels of anxiety, depression, nervousness, insomnia, and, to a lesser extent, stress. As noted by Lluch in 2022 [37], burnout levels among healthcare professionals increased from medium-high to high during the pandemic, while compassion fatigue went from medium to high. These factors had a significant negative impact on the well-being and quality of life of healthcare professionals. The stress and anxiety experienced by professionals, in general, not only influences their health but also has an impact on the health system. Due to the emotional impact of COVID-19 it is advisable to offer psychological help to the professionals ensuring not only their health, but also the health they offer [38].
Several sociodemographic variables like gender, profession, age, place of work, department of work and psychological variables like poor social support, and self-efficacy were associated with increased stress, anxiety, depressive symptoms, insomnia in healthcare workers. There is increasing evidence that suggests that COVID-19 can be an independent risk factor for stress in these professionals [39].

Yin and colleagues in their scoping review [40] highlight the importance of using Quality Improvement (QI) frameworks to guide response efforts during large-scale emergencies. QI is defined as "the use of deliberate and defined methods in continuous efforts to achieve measurable improvements in efficiency, effectiveness, performance, accountability, outcomes, and other quality indicators in services or processes" [40]. The review identified 26 relevant records related to Quality Improvement (QI) initiatives in emergency management during the COVID-19 pandemic. These cover five topics and, in order to fully reap the benefits of quality improvement methodologies, focus on both the individual project level and the organizational level, with a seamless integration of these approaches into the overall management philosophy and culture of the organization: 1) collaborative problem solving and analysis with stakeholders; 2) supporting learning and capacity development in QI; 3) learning from past emergencies; 4) implementing QI methods during COVID-19; and 5) evaluating performance using frameworks/indicators.
Collaborative problem-solving and analysis with stakeholders emerged as the most common topic, highlighting the importance of stakeholder engagement in facilitating public health emergency response. The review also identified sixteen records related to learning and capacity building, with a focus on improving capacity among individuals involved in the public health response to COVID-19. The records discussed various QI methods, tools and techniques to prepare participants for learning, including educational resources and training programs. Overall, the review concludes that improving access to educational resources and building capacity in QI may represent key actions [40].

Following Filip and her colleagues [41] there is a need to restructure public health care systems to be better prepared for other diseases. Systems need to be reshaped for efficient and capable management around five measures: (1) management (limiting entry to healthcare facilities to ensure the safety of patients and professionals), (2) protection (developing protocols and measures to retain, protect, and support patients and staff), (3) containment through transmission control and suppression (redirecting non-urgent cases from hospitals to outpatient facilities), (4) information (facilitating and coordinating communication between different professionals), and (5) support (developing best practice guidelines and legislation to coordinate global cooperative action) [41].

During the pandemic, there was a great need for training for professionals, as there was a need to respond to the challenges faced and to acquire the necessary skills and knowledge.
Traditional training methods were adapted to the context of the pandemic, taking into account the mandatory safety distance and the demand for short and effective training. In this context, the Hospital Universitario Puerta de Hierro-Majadahonda (Madrid, Spain) implemented a digital training strategy based on the production and publication of training pills through a mobile application [42]. The design of the training pills was based on mobile learning and microlearning teaching-learning methodologies, as useful and effective tools to respond to the training needs of a university hospital in a health emergency. Mobile learning is an advanced method of digital learning in which content is accessed through wireless devices. It is a support for the continuity of education and training. Microlearning is a variant of m-learning, which consists of the fragmentation of content into small units of digital information in a state of constant updating that deal with a specific topic, in a short period of time (no more than 15 minutes). Both tools have received huge success among health care workers [42].

Discussion

In this scoping review, the impact of COVID-19 on the European and global population emerges in its full force, resulting in a significant number of deaths and numerous mid- and long-term sequelae on the entire population.
The pandemic has highlighted the critical importance of managing health-related emergency events across multiple levels, including initial response, information management, communication, and resource preparedness and distribution. The lessons learned from this experience should guide future emergency management. One of the crucial takeaways is the importance of cooperation and collaboration between health authorities, governments, and the public. Effective and transparent communication, guidelines and proper preparation by healthcare professionals and government agencies are also essential to a successful response to future emergencies.

To accurately measure the impact of the pandemic on public health and investigate alternative policy options, it is crucial to have reliable death toll measurements. Reported deaths provide only a partial count of the total death toll, while excess mortality, which is the net difference between observed or estimated all-cause mortality during the pandemic and expected mortality based on past trends, provides a more accurate assessment of the pandemic's total mortality impact. A study published on Lancet [43] leveraged data from locations where all-cause mortality data were available from before and during the pandemic to estimate excess mortality at global and country-level due to the pandemic. They also explored the statistical relationship between excess

mortality rate and key covariates and population health-related metrics. The study found that by December 31, 2021, the estimated number of excess deaths due to COVID-19 was nearly 3 times greater than reported deaths. The magnitude of the excess mortality burden varied substantially between countries, with high excess mortality rates in eastern and central Europe, among others. Despite all GLIDE-consortium partner countries reporting a higher population vaccination rate than the European average, and in particular Italy and Spain had a primary course vaccination rate of about 80%, they reported a higher number of deaths than Germany and the Netherlands. Overall, we have to say that the differences in the number of deaths reported in each of these countries are likely the result of a complex interplay between many different factors and cannot be fully explained by vaccination rates alone. While vaccination is a crucial tool in controlling the spread of COVID-19 and reducing the severity of the illness, it is not a guarantee of complete protection against the virus. Additionally, the effectiveness of vaccines may vary based on factors such as the specific variant of the virus [44] that is circulating and individual differences in immune response.
Some of the factors that can contribute to the different mortality rates between these countries are: differences in the age distribution of the population, the prevalence of pre-existing health conditions, the quality of healthcare systems, the education of healthcare professionals and the psychological support provided to them, the timing, clarity and effectiveness of public health measures implemented to control the spread of the virus [45]. In vaccination campaigns some of these factors need to be carefully considered, for example it is crucial to balance the needs of high mortality/high-risk groups with the need to protect essential workers and maintain essential services.

In addition to vaccines, preventive measures put in place to counter the rapid spread of the virus have not always had the desired effect, mainly due to poor public adherence [16, 46]. This can be attributed to, among other things, a lack of shared consensus at international level [47]. In fact, not all countries have adopted these measures in the same way and with the same timing. For example, at the beginning of the pandemic, some countries underestimated the importance of social distancing and the use of masks, while others implemented these measures only after the virus had already spread widely. In other cases, errors were related to lack of resources or difficulty in coordinating actions among different regions or countries. For example, some countries had difficulty providing personal protective equipment to health workers or ensuring equitable access to testing and treatment. In addition, there have been some critical issues inherent in the measures themselves as was the case with the green pass and contact tracing apps [17, 48].
From what has been discussed, the COVID-19 pandemic has shown that it is important for governments and national authorities to take timely and coordinated action. They should work together to communicate a unified scientific message and avoid fragmented responses. This will help to build trust between governments, citizens, and the scientific community. It is also important to develop effective strategies for communication and information dissemination through modern channels, such as social media platforms.

The COVID-19 pandemic has generated a lot of conflicting opinions about available treatments due to the lack of specific information about the virus. As a result, many therapies were tried and tested empirically, with varying results. Some physicians followed their own experience and opinions rather than official guidelines, which may have been a result of the lack of clear and specific information, as well as the urgency to find lifesaving solutions.

While scientific studies were accelerated to find effective treatments, to date there is still no specific therapy approved for the treatment of COVID-19. This highlights the importance of a rigorous scientific approach in the research and development of new treatments. Developing specific treatments takes time and resources, COVID-19 experience has allowed for the recognition and understanding of this and that prevention is always the best initial strategy in health emergencies.
In the future, focusing on prevention and relying on robust scientific processes to develop effective specific treatments will be essential. Additionally, it's important to recognize that without controlled clinical studies, it's not possible to establish the efficacy and safety of any treatment. Therefore, official guidelines based on rigorous scientific evidence are necessary to ensure that patients receive the best possible care.
To better equip individuals to protect themselves, their families, and their communities, in the first stages of a pandemic, it is therefore important to build knowledge-based capacity through early education and enabling environments. This can be achieved by integrating the scientific basis of infectious disease prevention and control, hygiene, and public health into primary and lifelong education programs, starting from an early age and promoting safe and healthy behaviors. Additionally, health authorities can engage the health workforce to provide accurate health communication during times of crisis and invest in modern communication channels and tools such as video, social media, and games to improve communication and education efforts [49].

As extensively discussed in the results, COVID-19 infection as a multisystemic disease led to a number of long-term effects on various organs requiring rehabilitation. Although to date it is not yet possible to know with certainty what the long-term effects of the pandemic will be, cognitive impairment following COVID-19 is being increasingly recognized as an acute and possibly long-term sequelae of the disease. The virus may directly enter the brain or contribute to neuroinflammation through systemic mechanisms such as cytokine storm. COVID-19-related long-term olfactory dysfunction and early damage to olfactory and limbic brain regions suggest a pattern of degeneration similar to that seen in early stages of Alzheimer's disease, Parkinson's disease, and Lewy body dementia [50]. Biomarkers of COVID-19-induced cognitive impairment are currently lacking, but there is some limited evidence that SARS-CoV-2 could preferentially target the frontal lobes, as suggested by behavioral and dysexecutive symptoms, fronto-temporal hypoperfusion on MRI, EEG slowing in frontal regions, and frontal hypometabolism [50]. These data suggest a possible wave of post-COVID dementia in the coming decades, even if more research is needed to fully understand the mechanism and extent of this potential association. In addition, overall, the evidence suggests that COVID-19 can have a significant impact on mental health, with increased rates of anxiety, depression, post-traumatic stress disorder, and sleep disturbances among those who have been infected [33, 52].
The presented evidence suggests that the COVID-19 pandemic has posed an intricate challenge for disaster management and healthcare professionals, with a much greater impact in terms of size, scope, and transmission compared to other disasters. The response to this crisis has been complex and has been hindered by a shortage of established models and prior experience, which has put significant strain on existing systems. Countries' capacity to respond to the pandemic was uneven, with some countries having well-resourced and organized health systems, guaranteeing their populations acceptable levels of protection for life and health, while others had insufficient health coverage.The importance of having specialized and updated media and communication resources in the healthcare setting, that allow and facilitate the training of professionals with respect to action

protocols and clinical evidence with immediacy, has become evident. In this regard, future work should be aimed at improving the resources for producing content and measuring its impact on healthcare practice.

Raising healthcare professionals and public awareness of mental health and its role before, during, and after a major epidemic or outbreak is essential. Developing community-based mental health initiatives and programs that focus on mental health training and education can be particularly effective. By prioritizing preventive mental health, we can improve overall well-being and resilience, ultimately contributing to more effective pandemic and epidemic preparedness. Particular attention should be given to post-traumatic stress disorder, which is a common consequence of all emergency events. Therefore, educating health professionals but also the population, providing psychoeducation on the topic, is optimal in the perspective of possible new emergencies. Moreover, preventive mental health should become a key element to improve pandemic and epidemic preparedness. This can be achieved by strengthening the assessment of mental and psychological impact of public health and social measures prior to their implementation and establishing effective monitoring mechanisms [49].

Conclusions

The COVID-19 pandemic has presented a significant challenge in the 21st century. Our global society is more interconnected than ever, and emerging pathogens do not respect geopolitical boundaries. This pandemic has illustrated that infectious diseases are complex and influenced by various interconnected factors, revealing weaknesses in our health, socioeconomic, environmental, and political systems. To effectively respond to pandemics like COVID-19 and prepare for future public health threats, proactive investment in public health infrastructure and capacity is crucial. It is also essential to continue improving international surveillance, cooperation, coordination, and communication. To better prepare for future infectious threats, we need to maximize investment in training and harness the potential of emerging technologies. By doing so, we can enhance our ability to respond to public health crises and improve outcomes. Simulation exercises on a city level can be considered to identify gaps in training, skills, and operations, while multilateral, multidisciplinary exercises and training programmes can be developed to build future skill agendas. In conclusion we are called to shift our mindset and adopt new approaches different from what we are accustomed to.

References

1. Wu Z, McGoogan JM (2020) Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72 314 cases from the Chinese Center for Disease Control and Prevention. JAMA 323(13):1239–1242

2. Lai CC, Shih TP, Ko WC, Tang HJ, Hsueh PR (2020) Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and corona virus disease-2019 (COVID-19): the epidemic and the challenges. Int J Antimicrob Agents 55(3):105924.https://doi. org/10.1016/j.ijantimicag.2020.105924

3. Choi H, Qi X, Yoon SH, Park SJ, Lee KH, Kim JY et al (2020) Extension of coronavirus disease 2019 (COVID-19) on chest CT and implications for chest radiograph interpretation. Radiol Cardiothorac Imaging 2(2):e200107. https://doi.org/10.1148/ ryct.2020200107

4. Coronavirus disease (COVID-19) *World Health Organization.* [2020-09-26]. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/question-and-answers-hub/q-a-detail/q-a-coronaviruses.

5. Coronavirus disease 2019 (COVID-19): situation report, 46. *World Health Organization.* 2020. [2021-03-17]. https://apps.who.int/iris/handle/10665/331443.

6. WHO Coronavirus (COVID-19) Dashboard. World Health Organization. 2023. [2023-06-14]. https://covid19.who.int/?mapFilter=cases

7. Fatti e cifre sulla vita nell'Unione europea. [2023-06-14]. https://european-union.europa.eu/principles-countries-history/key-facts-and-figures/life-eu_

8. Coronavirus (COVID-19) Cases. Our world in data. [2023-06-14].https://ourworldindata.org/covid-cases

9. Gabutti G, d'Anchera E, De Motoli F, Savio M, Stefanati A. The Epidemiological Characteristics of the COVID-19 Pandemic in Europe: Focus on Italy. Int J Environ Res Public Health. 2021 Mar 13;18(6):2942. doi: 10.3390/ijerph18062942. PMID: 33805624; PMCID: PMC8000566.

10. Tobías, A. (2020). Evaluation of the lockdowns for the SARS-CoV-2 epidemic in Italy and Spain after one month follow up. *Science of the Total Environment*, *725*, 138539.

11. Guzzetta, G., Riccardo, F., Marziano, V., Poletti, P., Trentini, F., Bella, A., ... & COVID-19 Working Group. (2021). Impact of a nationwide lockdown on SARS-CoV-2 transmissibility, Italy. *Emerging infectious diseases*, *27*(1), 267.

12. Haas E.J., Angulo F.J., McLaughlin J.M., Anis E., Singer S.R., Khan F., Brooks N., Smaja M., Mircus G., Pan K., et al. Impact and effectiveness of mRNA BNT162b2 vaccine against SARS-CoV-2 infections and COVID-19 cases, hospitalisations, and deaths following a nationwide vaccination campaign in Israel: An observational study using national surveillance data. Lancet. 2021;397:1819–1829. doi: 10.1016/S0140-6736(21)00947-8.

13. Baden, L. R., El Sahly, H.M., Essink, B.,. Efficacy and Safety of the mRNA-1273 SARS-CoV-2 Vaccine. N Engl J Med. 2021;384(5):403-416. doi: 10.1056/NEJMoa2035389.

14. Post COVID-19 condition (Long COVID). World Health Organization. 2023. [2023-06-14]. https://www.who.int/europe/news-room/fact-sheets/item/post-covid-19-condition

15. Bahl, P., Doolan, C., de Silva, C., Chughtai, A. A., Bourouiba, L., & MacIntyre, C. R. (2022). Airborne or Droplet Precautions for Health Workers Treating Coronavirus Disease 2019?. The Journal of infectious diseases, 225(9), 1561–1568. https://doi.org/10.1093/infdis/jiaa189

16. Coroiu, A., Moran, C., Campbell, T., & Geller, A. C. (2020). Barriers and facilitators of adherence to social distancing recommendations during COVID-19 among a large international sample of adults. *PloS one*, *15*(10), e0239795. https://doi.org/10.1371/journal.pone.0239795

17. O'Connell, J., Abbas, M., Beecham, S., Buckley, J., Chochlov, M., Fitzgerald, B., Glynn, L., Johnson, K., Laffey, J., McNicholas, B., Nuseibeh, B., O'Callaghan, M., O'Keeffe, I., Razzaq, A., Rekanar, K., Richardson,

I., Simpkin, A., Storni, C., Tsvyatkova, D., Walsh, J., … O'Keeffe, D. (2021). Best Practice Guidance for Digital Contact Tracing Apps: A Cross-disciplinary Review of the Literature. *JMIR mHealth and uHealth*, *9*(6), e27753. https://doi.org/10.2196/27753

18. Tran, T. N., Wikle, N. B., Albert, E., Inam, H., Strong, E., Brinda, K., Leighow, S. M., Yang, F., Hossain, S., Pritchard, J. R., Chan, P., Hanage, W. P., Hanks, E. M., & Boni, M. F. (2021). Optimal SARS-CoV-2 vaccine allocation using real-time attack-rate estimates in Rhode Island and Massachusetts. *BMC medicine*, *19*(1), 162. https://doi.org/10.1186/s12916-021-02038-w

19. Struyf, T., Deeks, J. J., Dinnes, J., Takwoingi, Y., Davenport, C., Leeflang, M. M., Spijker, R., Hooft, L., Emperador, D., Domen, J., Tans, A., Janssens, S., Wickramasinghe, D., Lannoy, V., Horn, S. R. A., Van den Bruel, A., & CochraneCOVID-19 Diagnostic Test Accuracy Group (2022). Signs and symptoms to determine if a patient presenting in primary care or hospital outpatient settings has COVID-19. The Cochrane database of systematic reviews, 5(5), CD013665. https://doi.org/10.1002/14651858.CD013665.pub3

20. Bellino S. (2022). COVID-19 treatments approved in the European Union and clinical recommendations for the management of non-hospitalized and hospitalized patients. Annals of medicine, 54(1), 2856–2860. https://doi.org/10.1080/07853890.2022.2133162

21. Oliver, J. C., Silva, E. N., Soares, L. M., Scodeler, G. C., Santos, A. S., Corsetti, P. P., Prudêncio, C. R., & de Almeida, L. A. (2022). Different drug approaches to COVID-19 treatment worldwide: an update of new drugs and drugs repositioning to fight against the novel coronavirus. Therapeutic advances in vaccines and immunotherapy, 10, 25151355221144845. https://doi.org/10.1177/25151355221144845

22. Haddad, F., Dokmak, G., & Karaman, R. (2022). A Comprehensive Review on the Efficacy of Several PharmacologicAgents for the Treatment of COVID-19. Life (Basel, Switzerland), 12(11), 1758. https://doi.org/10.3390/life12111758

23. Jiang, Y., Zhao, T., Zhou, X., Xiang, Y., Gutierrez-Castrellon, P., & Ma, X. (2022). Inflammatory pathways in COVID-19: Mechanism and therapeutic interventions. MedComm, 3(3), e154. https://doi.org/10.1002/mco2.154

24. Coronavirus Disease 2019 (COVID-19). Treatment Guidelines. https://files.covid19treatmentguidelines.nih.gov/guidelines/covid19treatmentguidelines.pdf

25. Karekla, M., Höfer, S., Plantade-Gipch, A., Neto, D. D., Schjødt, B., David, D., Schütz, C., Eleftheriou, A., Pappová, P. K., Lowet, K., McCracken, L., Sargautytė, R., Scharnhorst, J., & Hart, J. (2021). The role of psychologists in healthcare during the COVID-19 pandemic: Lessons learned and recommendations for the future. European Journal of Psychology Open, 80(1-2), 5–17.

26. Pandolfi, S., Valdenassi, L., Bjørklund, G., Chirumbolo, S., Lysiuk, R., Lenchyk, L., Doşa, M. D., & Fazio, S. (2022). COVID-19 Medical and Pharmacological Management in the European Countries Compared to Italy: An Overview. International journal of environmental research and public health, 19(7), 4262. https://doi.org/10.3390/ijerph19074262

27. COVID-19 rapid guideline: managing the long-term effects of COVID-19. (2020). National Institute for Health and Care Excellence (NICE).

28. National Health Service. National guidance for post-COVID syndrome assessment clinics. *NHS*. 2021; Version 2.

29. World health organization. clinical management of Covid-19: living guideline, 15 september 2022. Geneva: World health organization; 2022.

30. Negrini, S., Kiekens, C., Cordani, C., Arienti, C., & DE Groote, W. (2022). Cochrane "evidence relevant to" rehabilitation of people with post COVID-19 condition. What it is and how it has been mapped to inform the

development of the World Health Organization recommendations. *European journal of physical and rehabilitation medicine*, *58*(6), 853–856. https://doi.org/10.23736/S1973-9087.22.07793-0

31. Staffolani, S., Iencinella, V., Cimatti, M., & Tavio, M. (2022). Long COVID-19 syndrome as a fourth phase of SARS-CoV-2 infection. *Le infezioni in medicina*, *30*(1), 22–29. https://doi.org/10.53854/liim-3001-3

32. Lugo-Agudelo LH, Cruz Sarmiento KM, Spir Brunal MA, Velásquez Correa JC, Posada Borrero AM, Fernanda Mesa Franco L, Di Dio Castagna Ianini R, Ramírez Pérez Lis PA, Vélez CM, Patiño Lugo DF, Gutenbrunner C. Adaptations for rehabilitation services during the COVID-19 pandemic proposed by scientific organizations and rehabilitation professionals. J Rehabil Med. 2021 Sep 16;53(9):jrm00228. doi: 10.2340/16501977-2865. PMID: 34427688; PMCID: PMC8638723.

33. Hossain MM, Tasnim S, Sultana A, Faizah F, Mazumder H, Zou L, McKyer ELJ, Ahmed HU, Ma P. Epidemiology of mental health problems in COVID-19: a review. F1000Res. 2020 Jun 23;9:636. doi: 10.12688/f1000research.24457.1. PMID: 33093946; PMCID: PMC7549174.

34. Pinazo-Hernandis S, Galvañ Bas A, Dosil Diaz C, Pinazo-Clapés C, Nieto-Vieites A, Facal Mayo D. El peor año de mi vida. Agotamiento emocional y burnout por la COVID-19 en profesionales de residencias. Estudio RESICOVID [The worst year of my life. Emotional exhaustion and burnout due to COVID-19 in nursing home professionals. RESICOVID study]. Rev Esp Geriatr Gerontol. 2022 Jul-Aug;57(4):224-229. Spanish. doi: 10.1016/j.regg.2022.06.001. Epub 2022 Jun 14. PMID: 35788285; PMCID: PMC9192792.

35. Danet A. Psychological impact of COVID-19 pandemic in Western frontline healthcare professionals. A systematic review. Med Clin (Barc). 2021 May 7;156(9):449-458. English, Spanish. doi: 10.1016/j.medcli.2020.11.009. Epub 2021 Jan 1. PMID: 33478809; PMCID: PMC7775650.

36. García-Iglesias, J. J., Gómez-Salgado, J., Martín-Pereira, J., Fagundo-Rivera, J., Ayuso-Murillo, D., Martínez-Riera, J. R., & Ruiz Frutos, C. (2020). Impacto del SARS-CoV-2 (Covid-19) en la salud mental de los profesionales sanitarios: una revisión sistemática. Rev Esp Salud Publica. 2020 Jul 23;94: e202007088. Spanish. PMID: 32699204.

37. Lluch, C., Galiana, L., Doménech, P., & Sansó, N. (2022, February). The impact of the COVID-19 pandemic on burnout, compassion fatigue, and compassion satisfaction in healthcare personnel: a systematic review of the literature published during the first year of the pandemic. In Healthcare (Vol. 10, No. 2, p. 364). MDPI. https://doi.org/10.3390/healthcare10020364

38. Santamaría, M. D., Ozamiz-Etxebarria, N., Rodríguez, I. R., Alboniga-Mayor, J. J., & Gorrotxategi, M. P. (2021). Impacto psicológico de la COVID-19 en una muestra de profesionales sanitarios españoles. Revista de psiquiatría y salud mental, 14(2), 106-112. ISSN 1888-9891, https://doi.org/10.1016/j.rpsm.2020.05.004.

39. Spoorthy, M. S., Pratapa, S. K., & Mahant, S. (2020). Mental health problems faced by healthcare workers due to the COVID-19 pandemic-A review. *Asian journal of psychiatry*, *51*, 102119. https://doi.org/10.1016/j.ajp.2020.102119

40. Yin, X.C., Pang, M., Law, M.P. *et al.* Rising through the pandemic: a scoping review of quality improvement in public health during the COVID-19 pandemic. *BMC Public Health* 22, 248 (2022). https://doi.org/10.1186/s12889-022-12631-0

41. Filip, R., Gheorghita Puscaselu, R., Anchidin-Norocel, L., Dimian, M., & Savage, W. K. (2022). Global Challenges to Public Health Care Systems during the COVID-19 Pandemic: A Review of Pandemic Measures and Problems. *Journal of Personalized Medicine*, *12*(8), 1295.

42. Revuelta-Zamorano, M., Vargas-Núñez, J. A., de Andrés-Gimeno, B., Escudero-Gómez, C., Rull-Bravo, P. E., Sánchez-Herrero, H., ... & Solís-Muñoz, M. (2021). Estrategias de formación durante la pandemia por covid-19 en un hospital universitario. *Metas de Enfermería*, 16-25.

43. COVID-19 Excess Mortality Collaborators (2022). Estimating excess mortality due to the COVID-19 pandemic: a systematic analysis of COVID-19-related mortality, 2020-21. Lancet (London, England), 399(10334), 1513–1536. https://doi.org/10.1016/S0140-6736(21)02796-3

44. Shao, W., Chen, X., Zheng, C., Liu, H., Wang, G., Zhang, B., Li, Z., & Zhang, W. (2022). Effectiveness of COVID-19 vaccines against SARS-CoV-2 variants of concern in real-world: a literature review and

meta-analysis. Emerging microbes & infections, 11(1), 2383–2392. https://doi.org/10.1080/22221751.2022.2122582

45. Kerr, S., Vasileiou, E., Robertson, C., & Sheikh, A. (2022). COVID-19 vaccine effectiveness against symptomatic SARS-CoV-2 infection and severe COVID-19 outcomes from Delta AY.4.2: Cohort and test-negative study of 5.4 million individuals in Scotland. Journal of global health, 12, 05025. https://doi.org/10.7189/jogh.12.05025

46. de Noronha, N., Moniz, M., Gama, A., Laires, P. A., Goes, A. R., Pedro, A. R., Dias, S., Soares, P., & Nunes, C. (2022). Non-adherence to COVID-19 lockdown: who are they? A cross-sectional study in Portugal. Public health, 211, 5–13. https://doi.org/10.1016/j.puhe.2022.07.001

47. Abu El Kheir-Mataria, W., El-Fawal, H. & Chun, S. Global health governance performance during Covid-19, what needs to be changed? a delphi survey study. Global Health 19, 24 (2023). https://doi.org/10.1186/s12992-023-00921-0

48. Campanozzi, L. L., Tambone, V., & Ciccozzi, M. (2022). A Lesson from the Green Pass Experience in Italy: A Narrative Review. Vaccines, 10(9), 1483. https://doi.org/10.3390/vaccines10091483

49. Imagining the future of pandemics and epidemics: a 2022 perspective. Geneva: World Health Organization; 2022. Licence: CC BY-NC-SA 3.0 IGO.

50. Kay L. M. (2022). COVID-19 and olfactory dysfunction: a looming wave of dementia?. Journal of neurophysiology, 128(2), 436–444. https://doi.org/10.1152/jn.00255.2022

51. Toniolo, S., Scarioni, M., Di Lorenzo, F., Hort, J., Georges, J., Tomic, S., Nobili, F., Frederiksen, K. S., & Management Group of the EAN Dementia and Cognitive Disorders Scientific Panel (2021). Dementia and COVID-19, a Bidirectional Liaison: Risk Factors, Biomarkers, and Optimal Health Care. Journal of Alzheimer's disease : JAD, 82(3), 883–898. https://doi.org/10.3233/JAD-210335

52. Tu, Y., Zhang, Y., Li, Y., Zhao, Q., Bi, Y., Lu, X., Kong, Y., Wang, L., Lu, Z., & Hu, L. (2021). Post-traumatic stress symptoms in COVID-19 survivors: a self-report and brain imaging follow-up study. Molecular psychiatry, 26(12), 7475–7480. https://doi.org/10.1038/s41380-021-01223-w